Entry and Exit With Information Externalities*
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Abstract

In the paper we analyze how the possibility of revealing information to a competitor alters the entry/investment behavior of a first entrant. We show that once it has entered the market, the firm might refrain from making further profitable investments in order to hide information from the competitor. Moreover, we show that before entering the market, the first entrant anticipates that there is a strategic advantage in choosing an initially small scale of entry: in this way it "commits" itself to revealing the true state of the market with its subsequent decisions and this fact is beneficial since it induces the competitor to postpone entry into market.

Keywords: Entry, Exit, Information Externalities, Wait and See, First Entrant, Strategic Behavior.
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1 Introduction

Market entry is a decision that typically involves uncertainty and publicly available information on, for instance, consumers' tastes, market size, stock of infrastructure or costs of doing business is not always a sufficient guide. In this case the availability of other sources of information is particularly important. Kinoshita and Mody (1997), in an empirical study on Japanese multinationals, show that other two sources of information have great influence in determining the decision of a firm to invest abroad: *direct experience*, that is, information gathered through past investment in the same market and *information externalities*, that is, information inferred from the behavior of other investors. In particular, as far as the latter source is concerned, the authors claim that the investment decision of a rival firm "... conveys the information that the rival considers the investment in a particular country to be a profitable venture, thus increasing the incentives to invest in that country to benefit from the same opportunity". The importance of the behavior of competitors in revealing the market conditions is illustrated also in Bardacke (1996). Commenting the decision of General Motors to locate its Asian hub in Thailand the author observes that "... the fact that 11 car manufacturers already operate in Thailand was a sign that the country's infamous physical infrastructure and labor bottlenecks could be overcome".[1] The importance of information externalities when deciding about entry into a market has been pointed out also in contexts different from FDI. In two different studies on the entry and exit behavior in the retailing sector, both Carree and Thurik (1996) and Nijkamp (2001) conclude that the probability of a firm entering increases if during the previous year a rival firm has entered the same market.[2] Interestingly, the authors obtain this empirical result even when controlling for other variables that possibly reveal information about the profitability of the market such as the incumbent's profitability and (a measure of) market growth.

[1] This sort of follow-the-leader behavior has been highlighted in many empirical papers dealing with FDI. For instance, Huang and Shirai (1994) show that firms investing in developing countries often take a wait and see attitude: they delay their investment decisions to observe the performances of early entrants. Similarly, Wheeler and Mody (1992) and Mody and Srinivasan (1996) find that the existing stock of foreign capital has a major impact on the decision of a firm to invest in a country.

[2] Toivanen and Waterson (2001) obtain a similar result in an empirical study on the UK counter service burger market.

As they point out previous entry works as a "demonstration effect": it signals the presence of profitable opportunities in the market.

Curiously, the issue of entry in a context in which firms can learn from the behavior of rivals has not been addressed in the theoretical literature. On the one hand, the industrial organization-oriented literature on entry does not consider the possibility of information externalities. Indeed, in most of the cases the analysis is performed assuming that there is no uncertainty[3] and when uncertainty is considered, it is assumed that it resolves exogenously for all the firms as time goes by.[4] On the other hand, the literature that focuses on the role and effects of the presence of information externalities does not consider that learning can occur among rival agents.[5] It is commonly assumed that the interaction among players is of a purely informational type; that is, information externalities are considered but pay-off externalities are not. In this context, for an agent the actual decisions of the others matter only because of the information they convey. The main consequence of this assumption is that an agent may strategically choose a wait and see strategy to induce the other to take a risky investment decision that reveals the state of the market but no other strategic behavior arises.[6]

This paper is a first attempt to study the issues of entry and exit of rival firms in a context where information externalities might arise. In the model, we consider two competing firms that have the opportunity to enter a market of unknown profitability. The uncertainty about the market conditions can be resolved in two ways: either through *direct experience*, that is, by entering the

[3]See, for instance, Tirole (1988) chapter 8.

[4]See Brander and Spencer (1992), Maggi (1996), McGahan (1993) and Somma (1999).

[5]See, among others, Alexander-Cook et al. (1998), Caplin and Leahy (1998), Chamely and Gale (1994), Gul and Lundholm (1995) and Rob (1991).

[6]In Rob (1991) and Alexander-Cook (1998) the link between agents is not purely informational; however, also in these cases no strategic behavior other than strategic waiting arises. Rob (1991) considers the entry behavior of a competitive industry in an uncertain environment. In his model firms do not act strategically and the entry rate is determined by the zero profit condition. In Alexander-Cook et al. (1998) it is assumed that firms enjoy pay-off complementarities. In this setting there can be strategic waiting but once a firm decides to enter the market there is no advantages in behaving strategically in order to fool the others. On the contrary, it has every advantage in communicating the true information to attract the other firms in the market and enjoy the pay-off complementarities.

market, or by inferring information from the behavior of a (informed) rival, that is, through *information externalities*. The main goal of our analysis is to study how the entry/investment behavior of a first entrant is altered because of the information it reveals to the competitor. We show that the investment decisions of this firm, both after as well as before entering the market, are altered due to the presence of information externalities. Once it has entered the market, the first entrant might refrain from making additional investment even when the market is profitable. Indeed, the firm anticipates that an increase in its investment level signals a profitable opportunity and thus it induces the competitor's entry. We show that the incentives to hide this information are higher the stronger the effect of competition and the larger the investment the first entrant has already in place. This last observation explains why the presence of information externalities makes it more beneficial for the first entrant to choose an initially small scale of entry. In this way, the firm "commits" itself to revealing the true profitability conditions once it has entered the market. The first entrant benefits from this fact because by "committing" to revealing more precise information it induces the competitor to play a wait and see strategy, that is, to postpone entry in order to learn more about the market profitability.

The paper is organized as follows. In Section 2, we present the outline of the model. In Section 3, we consider a simplified version of the model that highlights the main results of this paper. We characterize the equilibrium of the game as well as the strategic behavior of the first entrant. Section 4 discusses some possible extensions of the model. Finally, Section 5 is devoted to the conclusions. The proofs of the various results we highlight in the analysis can be found in the Appendix.

2 The model

We consider two rival firms that are deciding on whether to enter a market of uncertain profitability. The market is composed of 3 identical sites and entry in each site requires an irreversible investment I. The profits that are obtained in a site depend on the number of firms that are present and on the prevailing state of nature. There are three possible states of nature: bad, medium and good. Before entry, firms know that the three states are equally likely. Moreover, they know that the state of nature whatever it is, is common to all the sites belonging to the market. Uncertainty can be resolved only in two ways: directly through entry in at least one of the sites or indirectly by observing the decisions of an informed firm.

We consider a three-periods game. Firm A, the first entrant, plays at $t = 1$ and at $t = 2$, while firm B plays at $t = 2$ and at $t = 3$. Each of them maximizes the sum of pay-offs it gets in the various periods. We assume that firms do not discount future pay-offs; that is, the discount factor is assumed to be equal to one.

At $t = 1$, firm A chooses its initial scale of entry, that is, it chooses to enter any number $m^A \in \{0, 1, 2, 3\}$ of sites. Provided that $m^A \geq 1$, it observes the true state of nature before $t = 2$. If $m^A = 0$ is chosen, firm A obtains no new information. At $t = 2$, it can choose any couple of integers (out, in) such that $out \leq m^A$ and $in \leq \left(3 - m^A\right)$; that is, it can exit any number *out* of the sites it has entered at $t = 1$ and it can enter any number *in* of the sites it has not entered during the previous period. As we shall see, the following choices are particularly relevant: $Exit \equiv \left(m^A, 0\right)$, $Stay \equiv (0, 0)$ and $Enter \equiv \left(0, 3 - m^A\right)$. Also at $t = 2$, firm B chooses its initial scale of entry, that is, $m^B \in \{0, 1, 2, 3\}$. It takes this decision simultaneously with the $t = 2$ decision of firm A and after having observed m^A. At $t = 3$, it can choose any couple of integers (out, in) such that $out \leq m^B$ and $in \leq \left(3 - m^B\right)$. These choices have the same meaning as the ones we have described for firm A. Firm B observes the true state of nature between $t = 2$ and $t = 3$, provided that it plays $m^B \geq 1$. If $m^B = 0$ is chosen, then it can learn the information revealed by A's choice at $t = 2$. Clearly, this latter choice is informative provided that $m^A \geq 1$. We say that firm B plays *Wait and See* when it chooses $m^B = 0$ after observing that A has played $m^A \geq 1$.

Throughout the paper we will assume that the profits in each site satisfy the following assumptions. In the case of a bad state of nature, the per-period profits in a site are assumed to be strictly negative. In the medium state, the per-period profits are strictly positive but overall, that is summing up the profits that a firm collects in a site during all the periods in which it is active, they are not sufficient to cover the investment expenditure. Finally, when the state of nature is good, the per-period profits are sufficient to cover the investment expenditure. These assumptions are supposed to hold both for monopoly as well as for duopoly profits.

Moreover, we will assume that, in expected terms, entry is profitable even when duopoly profits are to be earned. That is, profits in the good state of nature are large enough to compensate the investment expenditures and the losses incurred in the case of a bad state and even when a firm is a duopolist.

One consequence of all these assumptions is that the first entrant is not able to deter the entry of the competitor. In other words, it implies that we focus on a scenario that resembles the accommodated entry case defined in Tirole (1988).

3 A Simplified Setting

In this section, we present a simplified setting that highlights the most interesting messages of the paper. In what follows, we normalize to 1 the per-period monopoly profits that are earned in a site in the case of the good state of nature. Moreover, we assume that in the case of the bad state of nature the per-period profits are negative but negligible and, similarly, that in the case of the medium state of nature they are positive but negligible. As we clarify shortly below, these latter two assumptions imply that when choosing their initial scale of entry firms only consider the profits they earn in the good state. We begin the analysis by considering a benchmark in which we assume that firms are not rivals.

3.1 Benchmark: firms are not rivals

When firms do not compete with each other (i.e. they are not rivals), the profits that are obtained in a site only depend on the prevailing state of nature. As a consequence, when taking its decisions, firm A disregards the behavior of B. Consider firm A choosing any $m^A \geq 1$ during the first period:[7] it pays $m^A(I)$, it earns $m^A(1)$ in the case of the good state and negligible profits in the case of the other two states. Therefore, the first period expected pay-off is $\frac{1}{3}m^A(1) - m^A(I)$. During the second period, firm A plays knowing the true state of nature and its optimal behavior can be easily characterized. When it of a good type (that is, when it has observed that the state of nature is the good one), firm A knows that it is optimal to be active in all the three sites. Therefore, it plays *Enter*

[7] It can be easily verified that choosing $m^A = 0$ is a dominated strategy.

if $m^A \in \{1,2\}$ was chosen at $t=1$ and *Stay* in case of $m^A=3$. When it is of a medium type, it chooses *Stay* to earn the positive (even though negligible) profits available in the sites it has already entered. Finally, when it is of a bad type, it plays *Exit* to avoid incurring in (negligible) losses. Therefore, when playing $m^A \geq 1$ at $t=1$, firm A anticipates that during the second period it will earn $\frac{1}{3}(3-(3-m^A)I)$. In addition to that, at $t=1$ firm A also anticipates that at $t=3$ it will earn $\frac{1}{3}(3)$, that is, it will earn a profit of 1 in all the three sites provided that the state of nature is the good one.

A similar reasoning applies to firm B when it chooses any $m^B \geq 1$. However, this firm has another option too. During the second period firm A plays knowing the true state of nature and thus, by choosing $m^B=0$, firm B can take advantage of the information that the behavior of the first entrant reveals. As just shown, after playing $m^A \in \{1,2\}$, firm A's behavior reveals the prevailing state of nature: the first entrant plays *Exit*, *Stay* or *Enter* depending on whether it is of a bad, medium or good type. On the contrary, after choosing $m^A=3$, firm A plays *Stay* both in the case of the medium as well as in the case of the good state. Therefore, when observing *Stay* firm B can infer that either the medium or the good state has occurred and it assigns probability $\frac{1}{2}$ to each of these two states of nature.

Proposition 1 characterizes the optimal initial scale of entry of the two firms; that is, the optimal decision of firm A and firm B at $t=1$ and $t=2$ respectively.[8] To compare it with the analysis of the next subsection we restrict our attention to the set of parameters such that $I \leq \frac{4}{5}$.[9]

Proposition 1 *Assuming that firms are not rivals, then: when* $I \leq \frac{1}{2}$, *firm A plays* $m^A=3$ *at* $t=1$ *and firm B plays* $m^B=3$ *at* $t=2$*; when* $\frac{1}{2} < I \leq \frac{4}{5}$, *firm A plays* $m^A=1$ *at* $t=1$ *and firm B plays* $Wait$ *and* See *at* $t=2$.

The benchmark highlights the "basic trade-off" that firms face when choosing their initial scale of entry: larger expected profits during the initial period

[8] Formally, Proposition 1 could be stated for $I < \frac{1}{2}$ and for $I > \frac{1}{2}$. Indeed, at the boundary $I=\frac{1}{2}$ the negligible profits in the bad and medium states would determine the optimal choice of the firms. Without loss of generality, we assume that when $I=\frac{1}{2}$ entering the 3 sites is optimal. A similar reasoning applies to Lemmata 2, 3 and 5 and to Proposition 6.

[9] This implies that for firm B the expected pay-off of playing m^B=1 at $t=2$ is positive.

vs lower expected investment expenditures. As we verify in the proof of Proposition 1, each firm prefers to enter an additional site provided that the following condition holds:

$$\frac{1}{3}(1) - I + \frac{1}{3}I \geq 0. \tag{1}$$

By entering an additional site the firm obtains larger expected profits during the initial period; that is, it obtains profits in the additional site during the entry period if the good state of nature has occurred. However, the expected investment expenditure is also larger: it pays the investment required to enter the additional site with certainty, while, by entering one site less this expenditure is incurred during the next period and only in the case of a good state of nature.

As a consequence, as shown in Proposition 1, when the investment required to enter each site is small, then both firms enter all the 3 sites as soon as they can; that is, they both choose the largest scale of entry. On the contrary, when I is larger, firms prefer more cautious entry patterns in order to collect additional information. Firm A enters just one site at $t = 1$, while firm B plays *Wait and See* to infer information by observing the first entrant's behavior.

3.2 Firms are rivals

When firms are rivals, the pay-off that is obtained in a site depends not only on the prevailing state of nature but also on the number of firms that are present. This fact alters the behavior of the two firms with respect to the benchmark.

Let us denote $(1 - R)$, with $0 \leq R \leq 1$, the per-period profits in a site in the case of the good state of nature and when both firms are present. Parameter R represents a reduced form for the effect of competition; the larger the R, the stronger the competition.

In what follows, we characterize the equilibrium of the game for all the parameters satisfying the following condition:

$$\frac{4(1 - R)}{5} \geq I \geq \frac{(1 - R)}{2}. \tag{2}$$

The first inequality in 2 assures that, in expected terms, entry is profitable even when duopoly profits are to be earned.[10] The second inequality implies that the investment expenditure is large enough to induce firm B to play *Wait and See* if firm A's behavior at $t = 2$ is going to reveal the true state of nature.[11]

In order to characterize the equilibrium of the game we proceed backwards by defining as first the equilibrium of the sub-games that firms play at $t = 2$. We need to consider three different sub-games depending on whether firm A has entered one, two or the three sites during the first period.

3.2.1 The equilibrium of the sub-games

As we verify in Lemmata 2, 3 and 5, the optimal behavior of firm A once it has learned that the state of nature is either bad or medium coincides with the one in the benchmark: it plays *Exit* in the former case and *Stay* in the latter. Similarly, also a good type of firm A prefers playing *Stay* when $m^A = 3$ was chosen during the first period. A deeper scrutiny has to be devoted to a good type of firm A playing once $m^A \in \{1, 2\}$ was chosen. Entry in the remaining sites is *per se* profitable; that is, the profits that are earned in these sites more than compensate the investment expenditure required to enter them. However, firm A recognizes that there is a signalling effect too. By playing *Enter* it reveals that the market is profitable and thus it induces the competitor to enter the three sites during the last period. As we show below, the optimal choice of a good type of firm A depends on the number of sites it has already entered and on the extent to which rivalry affects its profits.

Firm A entered one site during the first period

Lemma 2 shows that when $m^A = 1$ was chosen then the Perfect Bayesian Equilibrium (PBE) of the ensuing sub-game is separating.[12] Firm A plays *Exit*,

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[10] In particular, the first inequality in 2 assures that when A has played $m^A = 3$, then the expected profits of playing $m^B = 1$ are non-negative for firm B.

[11] The case $I < \frac{(1-R)}{2}$ is of little interest. It can be easily verified that for this range of parameters both firms enter the 3 sites as soon as they can.

[12] It would be possible to verify that requiring that the beliefs satisfy some "reasonable restrictions", then the one stated in Lemma 2 is the unique possible PBE of the sub-game. The same holds true for the equilibria stated in Lemmata 3 and 5. However, the proofs to verify the uniqueness of such equilibria are very cumbersome and do not add much to the analysis we are presenting. Therefore, such proofs have been omitted even though they are

Stay or *Enter* depending on whether it is of a bad, medium or good type respectively. Given that the true state of nature is going to be revealed firm B plays *Wait and See* and enters the three sites at $t = 3$ if *Enter* is observed.[13]

Lemma 2 *The PBE of the sub-game played at* $t = 2$ *given* $m^A = 1$ *is separating. Firm A plays Exit if it is of a bad type, Stay if it is of a medium type and Enter if it is of a good type. Firm B plays Wait and See and updates its beliefs in the following way:* $\mu(Bad/Exit) = 1$, $\mu(Medium/Stay) = 1$ *and* $\mu(Good/(out, in)) = 1$ *for any* $(out, in) \neq Exit$ *or Stay.*

Having entered only one of the sites, a good type of firm A has strong incentives to play *Enter*. Indeed, given the competitor's beliefs, the only reasonable alternative would be that of playing *Stay* to induce firm B into believing that the state of nature is the medium one. However, this choice is not profitable enough. To fool the competitor a good type of firm A has to give up entry in two profitable sites. Moreover, the advantage of fooling the competitor, that is the possibility of not facing its competition, can be enjoyed only in the site entered at $t = 1$.

Firm A entered two sites during the first period

The sub-game that firms play once $m^A = 2$ was chosen is similar to the one we have just discussed. However, this time for a good type of firm A the advantages to deviate from a separating equilibrium are much larger. Indeed, by playing *Stay* firm A induces the competitor not to enter the market and thus it earns monopoly profits in two sites rather than just in one. In addition to that, by playing such a strategy it gives up entry in only one profitable site and not in two. In this case, whether or not firm A is willing to signal the good state of nature by playing *Enter* depends on the extent to which competition affects its pay-off.

Lemma 3 *When* $R \leq \frac{2-I}{3} \equiv R^{Sep}$, *the PBE of the sub-game played at* $t = 2$ *given* $m^A = 2$ *is separating and coincides with the one characterized in Lemma*

available from the author upon request.

[13] In the Lemmata 2 and 3 we denote $\mu(j/(out, in))$ the probability that firm B assigns to the state of nature j once it has played *Wait and See* and firm A has played (out, in).

2. When $R > R^{Sep}$, then the PBE is semi-separating. Firm A plays Exit if it is of a bad type, Stay if it is of a medium type and it chooses Enter with probability x^* and Stay with probability $(1 - x^*)$ if it is of a good type. Firm B plays $m^B = 1$ with probability y^* and $Wait$ and See with probability $(1 - y^*)$. When it chooses $Wait$ and See, firm B updates its beliefs in the following way: $\mu\,(Bad/Exit) = 1$, $\mu\,(Medium/Stay) = \frac{1}{2-x^*}$, $\mu\,(Good/Stay) = \frac{1-x^*}{2-x^*}$ and $\mu\,(Good/\,(out, in)) = 1$ for any $(out, in) \neq Exit$ or Stay. Where $x^* = \frac{4-5I-2R}{3-3I-R}$ and $y^* = \frac{(I-2)+3R}{R}$.

When R is small, then the effect of the induced competition is not too large and therefore a good type enters the last site even though this fact signals to the competitor the presence of a profitable opportunity. The opposite holds when R is large. In this case, the entry of the competitor affects the first entrant's pay-off to such an extent that the latter firm prefers to deviate from the separating equilibrium and play *Stay*. This fact implies that separating is no longer an equilibrium of the sub-game. As shown in Lemma 3, when R is large, the equilibrium is semi-separating: a good type of firm A signals that the market is profitable by playing *Enter* with some probability and mimics the medium type by playing *Stay* with complementary probability. Simultaneously, firm B randomizes and plays $m^B = 1$ and $Wait$ *and See* with positive probability. In such an equilibrium, a good type of firm A is willing to play *Enter* since with some probability the competitor enters the market already at $t = 2$ and, therefore, it is not possible to fool it by imitating the medium type. Moreover, a good type of firm A is also willing to play *Stay* since in this way it deters the entry of the competitor with positive probability. Indeed, consider what happens when no firm enters nor exits any site at $t = 2$; that is, A plays *Stay* and B plays $Wait$ *and See*. In this case, firm B assigns a probability smaller than $\frac{1}{2}$ to the good state of nature since it knows that in equilibrium a medium type plays *Stay* with probability 1 and the same choice is taken by a good type but with a strictly smaller probability. We show in the Appendix that after observing *Stay* the beliefs of firm B about the good state of nature have worsened to such an extent that, in expected terms, entry is no longer profitable.

The next technical result will be useful when commenting the optimal choice of firm A at $t = 1$.

Lemma 4 *The probability according to which firm B chooses $Wait$ and See in the semi-separating equilibrium of Lemma 3, $(1 - y^*)$, is a decreasing function* *of R.*

As just said, a good type of firm A is willing to play *Stay* given that this choice deters the competitor's entry with a positive probability. Clearly, the stronger the effects of competition (the larger R) the greater the advantage of deterrence. Therefore, to keep a good type A indifferent between playing *Enter* or *Stay* a decrease in the probability of deterrence have to be associated with an increase in R.

Firm A entered three sites during the first period

The behavior of firm A once it has entered the three sites during the first period coincides with the one in the benchmark. It plays *Exit* in the case of the bad state and *Stay* in the case of either the medium or the good state. Such a behavior reveals too few information to induce firm B to choose *Wait and See*. Indeed, by observing that A plays *Stay* firm B is unable to infer whether the state of nature is either medium or good. Therefore, as we verify in the following Lemma 5, firm B prefers to enter the market already at $t = 2$.

Lemma 5 *The equilibrium of the sub-game played at $t = 2$ given $m^A = 3$, has the following characteristics: firm A plays Exit if it is of a bad type and Stay if it is of a medium or of a good type. Firm B plays $m^B = 1$.*

3.2.2 The optimal choice of firm A at $t = 1$

When choosing its initial scale of entry, firm A anticipates that on top of the "basic trade-off" described in the benchmark there is also a strategic effect to take into account: its decision at $t = 1$ affects the entry behavior of the competitor. In the Appendix we show that the first entrant prefers $m^A + 1$ to m^A provided that the following condition holds:

$$\left(\frac{1}{3}(1) - I + \frac{1}{3}I\right) + \frac{1}{3}\left(y\left(m^A\right) - y\left(m^A + 1\right)\right) R \geq 0, \tag{3}$$

where $y(i)$, with $i = m^A, m^A + 1$, indicates the probability of firm B playing $m^B = 1$ at $t = 2$ when firm A enters a number i of sites during the initial period. The first term of 3 coincides with expression 1 and represents the "basic trade-off". The second term is the strategic effect.

From the analysis of sub-section 3.2.1 we know that when firm A plays $m^A \in \{1, 2\}$, then the competitor chooses $Wait\ and\ See$ with probability 1 or with probability $(1 - y^*)$ depending on whether the separating or the semi-separating equilibrium is going to be played. On the contrary, when firm A plays $m^A = 3$, firm B enters one site already at $t = 2$. Therefore, due to the reaction of firm B, the first entrant benefits more from an initially small scale of entry: by playing $m^A \in \{1, 2\}$ rather than $m^A = 3$, firm A induces the competitor to play $Wait$ $and\ See$ and thus to postpone entry with a larger probability. In other words, small scale entry is strategically superior from the point of view of the first entrant. The intuition for this fact is that by entering with a small scale this firm "commits" itself to revealing more precise information during the following period thus increasing the benefits of a waiting strategy for the competitor.

Proposition 6 here below characterizes the optimal choice of firm A at $t = 1$; Figure 1 represents this choice graphically.[14]

Proposition 6 *The optimal choice of firm A at* $t = 1$ *is characterized as follows:*

i) when $R \leq R^{Sep}$:

- for $I > \frac{1}{2}$*: it plays* $m^A = 1$*;*

- for $I \leq \frac{1}{2}$*: it plays* $m^A = 2$*.*

ii) when $R > R^{Sep}$:

- for $I > \widetilde{I} \equiv 2R - 1$*: it plays* $m^A = 2$*;*

- for $I \leq \widetilde{I}$*: it plays* $m^A = 3$*.*

When the effect of competition is not too strong (case *i)*), $m^A = 1$ and $m^A = 2$ are strategically equivalent: after both choices the separating equilibrium is played and then in both cases the competitor chooses $Wait\ and\ See$ with probability 1. As a consequence, the basic trade-off drives firm A's decision: when the required investment is large it chooses $m^A = 1$ (Region 1 in Figure 1), while when I is smaller it chooses $m^A = 2$ (Region 2). As shown in Figure 1, case *ii)* of Proposition 6 occurs for small values of the investment expenditure. Due to the "basic trade-off", in this range of parameters $m^A = 1$ is dominated and firm A plays $m^A = 3$ when I is very low (Region 4) and $m^A = 2$ when the investment expenditure is larger (Region 3).

[14] Note that the set of parameters satisfying 2 lies between the $\frac{4(1-R)}{5}$ and $\frac{1-R}{2}$ lines.

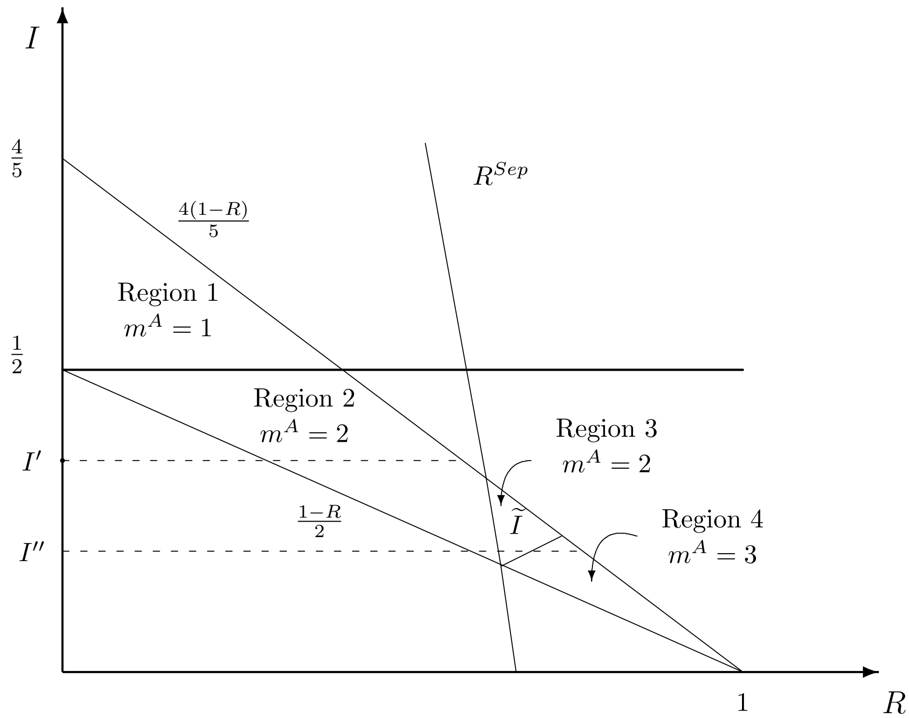

Figure 1: The optimal choice of firm A at $t = 1$

The impact of a stronger effect of competition

The larger the extent to which rivalry affects the pay-off of the first entrant the more this firm benefits from inducing the competitor to postpone entry into the market. In other terms, the larger the R the more important the strategic considerations. To appreciate fully how the choice of the first entrant varies with R we need to consider what happens for values of I smaller than $\frac{1-R}{2}$. For sake of brevity this case has been omitted in this version of this paper. However, it can be easily verified that for such low levels of the investment expenditure the two firms enter the three sites as soon they are allowed to play: firm A at $t = 1$ and firm B at $t = 2$. Therefore, considering a fixed value of the investment expenditure such as I' in Figure 1 one can see that: when R is low (region below the $\frac{1-R}{2}$ line) it is optimal for firm A to enter three sites at $t = 1$; as R gets larger (Region 2) $m^A = 2$ is optimal. The intuition for this result is trivial. As said above, the larger the effect of competition the more the first entrant benefits from entering with a small scale in order to delay the competitor's entry.

When R is larger than R^{Sep} there is another effect to consider. As we know from Lemma 4, the probability of firm B playing *Wait and See* in the semi-separating equilibrium decreases with R. Obviously, this fact has a detrimental effect on the pay-off that firm A gets when playing $m^A = 2$. Consider a value of the investment expenditure such as I'' in Figure 1. For values of R slightly greater than R^{Sep} firm A plays $m^A = 2$ (Region 3). However, as R enlarges the first entrant chooses $m^A = 3$ (Region 4). Indeed, even though it becomes more beneficial to induce the competitor to play *Wait and See*, as R gets larger the probability of firm B playing such a strategy shrinks thus making $m^A = 3$ the best option.

4 Discussion

In this section of the paper we discuss what happens if some of the assumptions of Section 3 are relaxed.

4.1 Non-negligible pay-offs in the case of the bad and medium states of nature

Assuming that the pay-off that firms obtain in the case of the bad and medium states of nature is non-negligible does not qualitatively alter the conclusions we have drawn in the "Simplified Setting".[15]

The equilibrium of the sub-games

The analysis performed in Subsection 3.2.1 largely applies to this more general framework. This fact implies that the main conclusion we have drawn is still valid: the smaller the initial scale of entry and the lower the effect of competition, the larger the incentives for the first entrant to reveal that the state of nature is good by playing *Enter*. Indeed, under the assumptions of Section 2, a bad and a medium type still find it optimal to play *Exit* and *Stay*, respectively. Therefore,

[15] A more formal analysis of the discussion in this sub-section is available on request

a good type of firm A faces exactly the same trade-off as in the previous analysis and thus: it plays *Enter* if $m^A = 1$ was chosen or in the case of $m^A = 2$ if $R \leq R^{Sep}$. When $R > R^{Sep}$ and if $m^A = 2$ was chosen, then the equilibrium of the sub-game is semi-separating and a good type of firm A randomizes attaching positive probability to both *Enter* and *Stay*. The only possible novel aspect with respect to the previous analysis occurs when firm A plays $m^A = 3$: it might happen that firm B finds it optimal to play *Wait and See* in this case too. Indeed, the behavior of the first entrant at $t = 2$ reveals whether the state of nature is bad or not: firm A plays *Exit* if it is of a bad type and *Stay* otherwise. Therefore, provided that the losses in the bad state are large enough, it might be optimal for firm B to play *Wait and See* even when firm A chose $m^A = 3$.

The optimal choice of firm A at $t = 1$

Having non-negligible per-period profits in the case of the bad and medium states of nature has obvious consequences on the basic trade-off described in the benchmark. The larger the profits in the medium state the more firms prefer to enter with a large initial scale. Contrarily, the larger the losses in the bad state, the better small scales of entry perform. In terms of the strategic effect, it is still true that by entering with a small scale firm A increases the probability of the competitor playing *Wait and See* and, in particular, choosing $m^A = 1$ always induces the competitor to postpone entry with probability 1. As noted above, under some circumstances $m^A = 3$ also induces the competitor to play *Wait and See*. However, this fact occurs provided that the losses in the bad state are large enough and, therefore, in these circumstances $m^A = 3$ is too risky for firm A and tends to be preferred by smaller scales of entry.

4.2 Non-uniformly distributed priors

Assuming that the three states of nature are not equally likely leads to consequences that are similar to those we have just discussed for the case on non-negligible pay-offs in the bad and medium states of nature. Under the assumptions of Section 2, the equilibrium of the sub-game that firms play once $m^A \in \{1, 2\}$ is chosen is unchanged for the same reasons as those we pointed out in Sub-section 4.1.[16] Similarly, firm B might choose *Wait and See* even when firm A plays $m^A = 3$. Indeed, provided that the prior probabilities of the medium and the good states are different, the choice *Stay* is more informative: the probability that the state is good (or medium) once *Stay* has been observed is different from $\frac{1}{2}$.

Turning to the optimal initial scale of entry, remarks similar to those we have made above apply. Firms are more prone to enter with a larger scale the higher the probability of the good state and the smaller the probability of the bad state.[17] Moreover, in all the cases in which $m^A = 3$ induces the competitor to choose *Wait and See*, then playing $m^A \in \{1, 2\}$ is not strategically superior from the point of view of the first entrant. However, the information that the competitor obtains by playing *Wait and See* once firm A has chosen $m^A \in \{1, 2\}$ is always superior. The two coincide if and only if the probability of the medium state of nature is 0. Therefore, even if it is reduced, the strategic advantage of entering with a small scale vanishes for all the relevant range of parameters only when there are just two states of nature: the bad and the good.

4.3 Symmetric firms

Consider what happens to the game we have analyzed in the case of the two firms being symmetric, that is, they can both play starting from period $t = 1$ and, therefore, there is no exogenous first and second entrant. To keep the analysis strategically equivalent to that of the previous sections, consider that the two firms are allowed to choose their entry strategies in two subsequent periods at most. In this case, it can be easily verified that under the assumptions of the "Simplified Setting" both firms enter the market with some scale from the first period and neither of them would play *Wait and See*. Indeed, in this symmetric setting in order to receive information about the market conditions a firm has to wait during two periods rather then just one. However, one needs to stress

[16] Clearly what changes are the probabilities according to which firms randomize in the semi-separating equilibrium

[17] Obviously, the effect of changes in the probability of the medium state is ambiguous. If it enlarges to the detriment of the probability of the bad state it makes large scale entry more beneficial, while if it reduces the probability of the good state it makes small scale entry more likely to be preferred

that this result depends on the assumptions we have imposed in Section 3. In particular, the ex-ante expected profitability is too large to induce one firm to wait for two periods. Contrarily, if the ex-ante expected profitability is not so large then things change drastically. In a previous version of this paper we have dealt with such an issue.[18] We have considered the presence of just two states of nature, the medium and the good and, the respective prior probabilities being $0 < p < 1$ and $0 < 1 - p < 1$, we have shown that, provided that the effect of competition is not too strong, then the set of parameters for which an endogenous first-second entrant structure arises in equilibrium is larger in the case of rivalry than in the benchmark. That is, we are more likely to have an equilibrium in which one firm enters at $t = 1$, while the other plays $Wait\ and\ See$ for two periods when firms are competing rather than when there are no pay-off externalities. The intuition for this result is twofold. On the one hand, the opportunity cost of playing $Wait\ and\ See$ is lower when there is rivalry. Indeed, in this case when waiting a firm is giving up potential duopoly rather than monopoly profits. On the other hand, the second and more interesting reason for the result is derived from the analysis we have performed in this paper. Due to strategic reasons the (endogenous) first entrant is more willing to enter with a small scale and "commit" itself to revealing the good state of the market later on. In turn, this fact makes it more beneficial for a (endogenous) second entrant to choose $Wait\ and\ See$.

4.4 Pay-off Complementarities

In a previous version of this paper,[19] we showed that in case of pay-off complementarities (R is negative) strategic considerations make $m^A = 3$ a more beneficial choice for the first entrant.[20] The intuition for this fact is opposite to the one we have in case of rival firms. Indeed, by "committing" itself to reveal less precise information the first entrant induces the other firm to enter already at $t = 2$ so that the pay-off complementarities are enjoyed starting from the second period. This result reminds us of the one obtained in Alexander-Cook et al.

[18] See Comino (2000).

[19] See Comino (2000).

[20] Clearly, when $R < 0$, a good type of firm A is always willing to play *Enter* and then the equilibrium of the sub-game played at $t = 2$ once $m^A \in \{1, 2\}$ was chosen is always separating.

(1998), where the authors show that a firm prefers not to acquire information to "commit" in order not to incur in the cost of revealing it. However, the intuition of their result is rather different. By not acquiring information a firm induces others to acquire it and to incur the costs of revealing it. Thus, in their case it is a free-rider argument that explains the strategic behavior of firms.

5 Conclusions

A significant empirical literature has pointed out that when deciding about entry in a market of unknown profitability, firms often take a wait and see attitude in order to learn information from the behavior of competitors. In other words, information externalities are a relevant channel through which firms try to learn the profitability conditions of the market they are targeting. In this paper we have proposed a first attempt to analyze the issue of entry in a context in which information externalities might arise. In particular, we have aimed at studying how the possibility of revealing information to a competitor alters the entry/investment behavior of a first entrant. We have shown that the choices of this firm, both after as well as before having entered the market, are altered. The decision of increasing its investment level once it is already located in the market is a clear signal that the market condition are favorable. Therefore, in order to hide this information to the competitor, the first entrant might refrain from making further profitable investments. We have pointed out that the incentives behave in this manner are higher the stronger the effect of competition is and the larger the investment the first entrant has already in place. In turn, this last observation gives the intuition of why the presence of possible information externalities makes it strategically superior for the first entrant to choose an initially small scale of entry. In this way, the firm "commits" itself to revealing the true profitability conditions once it has entered the market. The first entrant benefits from this fact because by "committing" to reveal more precise information it induces the the competitor to play a wait and see strategy, that is, to postpone entry in order to learn more about the market profitability.

6 Appendix

Proof of Proposition 1

As shown in the text, by playing any $m^A \geq 1$ firm A expects $\frac{1}{3}m^A(1) - m^A(I) + \frac{1}{3}\left(3 - (3 - m^A)I\right) + \frac{1}{3}(3)$ and, therefore, it prefers $m^A + 1$ to m^A provided that $\frac{1}{3}(1) - I + \frac{1}{3}(I) \geq 0$. This fact implies that the optimal choice of the first entrant is $m^A = 3$ if $I \leq \frac{1}{2}$ and $m^A = 1$ otherwise.[21] Similarly, when playing $m^B \geq 1$ at $t = 2$ firm B expects $\frac{1}{3}m^B(1) - m^B(I) + \frac{1}{3}\left(3 - (3 - m^B)I\right)$. The pay-off firm B obtains by playing $m^B = 0$ depends on the choice of firm A at $t = 1$. When $I > \frac{1}{2}$, firm A plays $m^A = 1$ and it reveals the state of nature during the following period. In this case, when choosing $m^B = 0$ firm B expects $\frac{1}{3}\left(3(1 - I)\right)$ since it anticipates that it will enter three sites at $t = 3$ if *Enter* is observed and none otherwise. Condition $I > \frac{1}{2}$ guarantees that $m^B = 0$ is preferred to any $m^B \geq 1$. When $I \leq \frac{1}{2}$, firm A plays $m^A = 3$ and during the following period it plays *Exit* in case of the bad state and *Stay* in case of either the medium or the good. In this case, when playing $m^B = 0$ firm B anticipates that if *Exit* is observed then it will not enter any site, while it will enter the three sites at $t = 3$ in case of observing *Stay*. Therefore, evaluated at $t = 2$ the choice of playing $m^B = 0$ yields an expected pay-off of $\frac{2}{3}\left(\frac{1}{2}(3) - 3I\right)$. Condition $I \leq \frac{1}{2}$ implies that it is optimal to play $m^B = 3$.

Proof of Lemma 2

In equilibrium, by playing any m^B firm B expects $\frac{1}{3}m^B(1 - R) - m^B I + \frac{1}{3}\left(3(1 - R) - \left(3 - m^B\right)I\right)$. Condition 2 implies that m^B is preferred to $m^B + 1$ and, therefore, that $m^B = 0$ is firm B's best response. For the bad and the medium types of firm A it is straightforward to check that *Exit* and *Stay* are respectively optimal. A good type of firm A obtains a continuation pay-off of $3 - 2I + 3(1 - R)$ by playing according to the equilibrium. Given the beliefs of firm B, the only reasonable deviation from the equilibrium strategy for a good type is to play *Stay*. The continuation pay-off it obtains in this case is 2 which is certainly less than what it earns in equilibrium.

Proof of Lemma 3

When $R \leq R^{Sep}$ the equilibrium is separating. By playing any m^B firm B obtains an expected pay-off of $\frac{1}{3}m^B(1 - R) - m^B I + \frac{1}{3}\left(3(1 - R) - \left(3 - m^B\right)I\right)$

[21] It would be easy to verify that $m^A = 0$ is a dominated strategy.

and condition 2 implies that $m^B = 0$ is its best response. For the bad and the medium types of firm A it is straightforward to check that *Exit* and *Stay* are respectively optimal. In equilibrium, a good type of firm A obtains a continuation pay-off of $3-I+3(1-R)$. Given the beliefs of the competitor, the only reasonable deviation from the equilibrium strategy for a good type is to play *Stay* which yields a continuation pay-off of 4. Condition $R \leq R^{Sep}$ implies that a good type of firm A prefers to play *Enter* rather than *Stay*.

In the semi-separating equilibrium a good type of firm A plays *Enter* with probability x and *Stay* with probability $1-x$. Therefore, firm B expects $x\left(\frac{1}{3}(1-R) - I + \frac{1}{3}\left(3(1-R)-2I\right)\right) + (1-x)\left(\frac{1}{3}(1) - I + \frac{1}{3}\left(2(1-R)+1-2I\right)\right)$ when playing $m^B = 1$.[22] By playing $m^B = 0$, firm B's expected pay-off is $x\left(\frac{1}{3}(3(1-R)-3(I))\right)$, that is, firm B anticipates that it will enter the 3 sites at $t=3$ provided that *Enter* is observed and none otherwise. Choosing not to enter the market after observing *Exit* is optimal since firm B infers that the bad state has occurred with probability 1, while we show shortly below that the same choice is optimal even after observing that firm A plays *Stay*. Firm B is indifferent at $t=2$ between $m^B = 1$ and $m^B = 0$ provided that a good type of firm A plays *Enter* with probability $x^* = \frac{4-5I-2R}{3-3I-R}$ and *Stay* with complementary probability. Condition 2 assures that $x^* \in (0,1)$. To complete the characterization of firm B's behavior we need to check that it is optimal not to enter any site at $t=3$ if at $t=2$ it has played $m^B = 0$ and firm A has played *Stay*. According to the Bayes rule $\mu\left(Medium/Stay\right) = \frac{1}{2-x^*}$ and $\mu\left(Good/Stay\right) = \frac{1-x^*}{2-x^*}$. Entry in any site is not profitable provided that $\frac{1-x^*}{2-x^*}(1) < I$, that is, provided that $\frac{1-R-I^2}{3-R-3I} > 0$. This last inequality holds true under condition 2. Consider now firm A. It is straightforward to verify that for the bad and the medium types *Exit* and *Stay* are respectively optimal. Given the beliefs of the competitor, for a good type of firm A *Enter* dominates any other choice different from *Stay*. By playing *Enter* it expects $y\left(2+(1-R)-I+3(1-R)\right) + (1-y)\left(3-I+3(1-R)\right)$, while by playing *Stay* it expects $y\left(2+2(1-R)\right) + (1-y)4$. The good type of firm A is indifferent between these two choices provided that B plays $m^B = 1$ with probability $y^* = \frac{(I-2)+3R}{R}$ and $m^B = 0$ with complementary probability. Conditions 2 and $R > R^{Sep}$ guarantee that $y^* \in (0,1)$.

[22] It can be easily verified that condition 2 implies that $m^B = 1$ is preferred to both $m^B = 2$ and $m^B = 3$.

Proof of Lemma 4

Condition 2 guarantees that $\frac{\partial(1-y^*)}{\partial R} = \frac{-2+I}{R^2}$ is negative.

Proof of Lemma 5

Given the equilibrium strategy of the first entrant, when playing $m^B = 0$ firm B expects a pay-off of 0 since it anticipates that it will not enter any site at $t = 3$. Indeed, if *Exit* is observed, then firm B infers that the bad state has certainly occurred. When *Stay* is observed, then firm B will assign probability $\frac{1}{2}$ to the medium and good states and, conditional on these probabilities, entry in a site at $t = 3$ is not profitable since condition 2 implies that $\frac{1}{2}(1-R) - I < 0$.[23] By playing any $m^B \geq 1$ firm B obtains an expected pay-off of $\frac{1}{3}m^B(1-R) - m^B(I) + \frac{1}{3}\Big(3(1-R) - (3-m^B)I\Big)$. Condition 2 guarantees that $m^B = 1$ is preferred to both $m^B = 0$ and $m^B \in \{2, 3\}$. It is straightforward to verify that the optimal choice for a bad type of firm A is to play *Exit*, while *Stay* is optimal for both a medium and a good type.

Proof of Proposition 6

To ease the presentation we make use of the following notation. Condition (2) is substituted by $\overline{I} \geq I \geq \underline{I}$, where $\overline{I} \equiv \frac{4}{5}(1-R)$ and $\underline{I} \equiv \frac{1-R}{2}$. Conditions $R \leq R^{Sep}$ and $R > R^{Sep}$ are substituted by $I \leq I^{Sep}$ and $I > I^{Sep}$ respectively, where $I^{Sep} \equiv 2 - 3R$.

We start the proof by verifying that the sets of parameters defining cases *i*) and *ii*) are non-empty. Note that $\underline{I} \leq I^{Sep}$ provided that $R \leq \frac{3}{5}$, $I^{Sep} \leq \overline{I}$ provided that $R \geq \frac{6}{11}$, while $\underline{I} \leq \overline{I}$ holds for any $R \geq 0$. Therefore, case *i*) exists provided that $R \leq \frac{3}{5}$ and it is defined for $\underline{I} \leq I \leq \overline{I}$ when $R < \frac{6}{11}$ and for $\underline{I} \leq I \leq I^{Sep}$ when $\frac{6}{11} \leq R \leq \frac{3}{5}$. Case *ii*) exists provided that $R \geq \frac{6}{11}$ and it is defined for $I^{Sep} < I \leq \overline{I}$ for $\frac{6}{11} \leq R \leq \frac{3}{5}$ and for $\underline{I} \leq I \leq \overline{I}$ for $R > \frac{3}{5}$.

- *case i): $I \leq I^{Sep}$:*

By playing $m^A = 3$ firm A obtains an expected pay-off of $\frac{1}{3}(3) - 3(I) + \frac{1}{3}(2 + (1-R)) + \frac{1}{3}(3(1-R))$, while by playing $m^A \in \{1, 2\}$ it obtains $\frac{1}{3}(m^A) - m^A(I) + \frac{1}{3}\Big(3 - (3-m^A)I\Big) + \frac{1}{3}(3(1-R))$. The choice $m^A = 2$ is preferred to

[23] Note that if the second inequality of condition 2 is not verified, that is if $I \leq \frac{1-R}{2}$ holds true, then by playing $m^B = 0$ firm B obtains a strictly positive pay-off. Indeed, upon observing *Stay* it would be optimal for this firm to enter the three sites at $t = 3$. However, also in this case it $m^B = 1$ is preferred to $m^B = 0$ and therefore it does happen that firm B plays *Wait and See* once A has chosen $m^A = 3$.

$m^A = 3$ if and only if $\frac{1}{3}(1) - I + \frac{1}{3}I - \frac{1}{3}R \leq 0$ which holds true since $I \geq \underline{I}$. Moreover, $m^A = 2$ is preferred to $m^A = 1$ provided that $\frac{1}{3}(1) - I + \frac{1}{3}I \geq 0$, that is, provided that $I \leq \frac{1}{2}$.

One can check that the following conditions hold: $\frac{1}{2} \leq I^{Sep}$ when $R \leq \frac{1}{2}$ and $\frac{1}{2} \leq \overline{I}$ when $R \leq \frac{3}{8}$. Therefore, the optimal choice of firm A is:

- when $R < \frac{3}{8}$: $m^A = 2$ for $\underline{I} \leq I \leq \frac{1}{2}$ and $m^A = 1$ for $\frac{1}{2} < I \leq \overline{I}$;
- when $\frac{3}{8} \leq R < \frac{6}{11}$: $m^A = 2$ for $\underline{I} \leq I \leq \overline{I}$
- when $\frac{6}{11} \leq R \leq \frac{3}{5}$: $m^A = 2$ for $\underline{I} \leq I \leq I^{Sep}$.

- *case ii):* $I > I^{Sep}$:

The pay-offs firm A obtains when playing either $m^A = 3$ or $m^A = 1$ coincide with those in case i). By playing $m^A = 2$ it obtains $\frac{1}{3}(2) - 2(I) + \frac{1}{3}(3 - y^* R - I) + \frac{1}{3}(3(1 - R))$, where y^* is defined in Lemma 3. Firm A prefers $m^A = 2$ to $m^A = 1$ provided that $1 - R - I \geq 0$, which holds true since $I \leq \overline{I}$. Moreover, $m^A = 3$ is preferred to $m^A = 2$ provided that $\frac{1}{3}(1) - I + \frac{1}{3}(I) + \frac{1}{3}((y^* - 1)R) \geq 0$, that is provided that $I \leq \widetilde{I}$, where $\widetilde{I} \equiv 2R - 1$.

One can check that $\widetilde{I} \leq \overline{I}$ when $R \leq \frac{9}{14}$, while conditions $\widetilde{I} \leq I^{Sep}$ and $\widetilde{I} \leq \underline{I}$ hold when $R \leq \frac{3}{5}$. Therefore, the optimal choice of firm A is:

- when $\frac{6}{11} \leq R \leq \frac{3}{5}$: $m = 2$ for $I^{Sep} < I \leq \overline{I}$;
- when $\frac{3}{5} < R \leq \frac{9}{14}$: $m^A = 3$ for $\underline{I} \leq I \leq \widetilde{I}$ and $m^A = 2$ for $\widetilde{I} < I \leq \overline{I}$;
- when $R > \frac{9}{14}$: $m^A = 3$ for $\underline{I} \leq I \leq \overline{I}$.

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